CLAIMS

We claim:

1. In a video encoder, a computer-implemented method for encoding video at any of multiple spatial resolutions, the method comprising:

encoding at least one frame in a sequence of plural video frames at a first spatial resolution; and

encoding at least one other frame in the sequence of plural video frames at a second spatial resolution;

wherein the second spatial resolution differs from the first spatial resolution, and wherein the encoder chooses the second spatial resolution from a set of plural spatial resolutions to reduce blocking artifacts in the sequence of video frames.

2. The method of claim 1 wherein the second spatial resolution comprises a vertical resolution with a vertical scaling factor and a horizontal resolution with a horizontal scaling factor, and wherein the vertical scaling factor differs from the horizontal scaling factor.

3. The method of claim 1 wherein the encoder switches to the second spatial resolution based at least in part on bitrate criteria.

4. The method of claim 1 wherein the encoder switches to the second spatial resolution based at least in part on high-frequency content criteria.

5. The method of claim 1 wherein the encoder switches to the second spatial resolution based at least in part on quantization step size criteria.

6. The method of claim 1 wherein a frame encoded at the second spatial resolution is down-sampled from the first spatial resolution using a down-sampling filter.

7. The method of claim 6 wherein the frame encoded at the second spatial resolution is down-sampled using fractional-rate down-sampling.

8. The method of claim 6 wherein the down-sampling filter comprises an even-numbered quantity of filter taps.

9. The method of claim 6 wherein the down-sampling filter is a 6-tap filter.

10. The method of claim 6 wherein the frame encoded at the second spatial resolution is down-sampled in a horizontal direction prior to being down-sampled in a vertical direction.

11. The method of claim 6 further comprising calculating new dimensions for the frame encoded at the second spatial resolution.

12. The method of claim 1 wherein a frame encoded at the second spatial resolution is up-sampled from the first spatial resolution using an up-sampling filter.

13. The method of claim 12 wherein the up-sampling filter is a 10-tap filter.

14. The method of claim 1 wherein the encoding at least one other frame at a second spatial resolution is indicated by a signal code.

15. The method of claim 1 further comprising, including a flag in a header for the sequence of plural video frames, wherein the flag indicates that the plural frames in the sequence are encoded using more than one spatial resolution.

16. The method of claim 1 wherein the first and second spatial resolutions are selected from a group comprising more than two spatial resolutions.

17. The method of claim 1 further comprising encoding a frame in the sequence of plural video frames at a third spatial resolution.

18. The method of claim 1 wherein the at least one other frame comprises a bi-directionally predicted frame.

19. A computer-readable medium having stored thereon computer-executable instructions for causing a computer programmed thereby to perform the method of claim 1.

20. A multi-resolution method for encoding video, the method comprising:

encoding a first part of a frame in a sequence of plural video frames at a first spatial resolution; and

encoding a second part of the frame in the sequence of plural video frames at a second spatial resolution;

wherein the second spatial resolution differs from the first spatial resolution.

21. The method of claim 20 wherein the first part of the frame comprises high-frequency content, and wherein the first spatial resolution is full resolution.

22. The method of claim 20 wherein the encoding the first part comprises applying a first filter to the first part, and wherein the encoding the second part comprises applying a different filter to the second part.

23. The method of claim 20 further comprising signaling the first spatial resolution with a first code in a bitstream, and signaling the second spatial resolution with a second code in the bitstream.

24. The method of claim 20 wherein the frame in the sequence is a bi-directionally predicted frame.

25. In a video encoder, a computer-implemented method for signaling spatial resolutions in an encoded video sequence, the method comprising:

including a first code in a bitstream, wherein the first code indicates a first spatial resolution for a first frame encoded at the first spatial resolution; and

including a second code in the bitstream, wherein the second code indicates a second spatial resolution for a second frame encoded at the second spatial resolution;

wherein the second spatial resolution differs from the first spatial resolution, and wherein the encoder chooses the second spatial resolution from a set of plural spatial resolutions to reduce blocking artifacts in the sequence of video frames.

26. The method of claim 25 wherein the second spatial resolution comprises a horizontal resolution and a vertical resolution, and wherein the including the second code comprises:

including a horizontal scaling factor code in the bitstream indicating a scaling factor for the horizontal resolution; and

including a vertical scaling factor code in the bitstream indicating a scaling factor for the vertical resolution.

27. The method of claim 25 wherein the second code is a frame-level fixed-length code.

28. The method of claim 25 wherein the second code is a frame-level variable-length code with a code length, and wherein the code length varies based on a probability of occurrence of the second spatial resolution.

29. The method of claim 25 further comprising:

including a sequence code in the bitstream, wherein the sequence code indicates whether multi-resolution encoding is used in the encoded video sequence.

30. The method of claim 25 further comprising:

including a filter code in the bitstream, wherein the filter code indicates a re-sampling filter to be used for decoding.

31. A computer-readable medium having stored thereon computer-executable instructions for causing a computer programmed thereby to perform the method of claim 25.

32. A method for signaling spatial resolutions in a bitstream for an encoded video sequence, the method comprising:

including a first signal in the bitstream, the first signal indicating a first spatial resolution for a first part of a frame in the encoded video sequence; and

including a second signal in the bitstream, the second signal indicating a second spatial resolution for a second part of the frame in the encoded video sequence;

wherein the second spatial resolution differs from the first spatial resolution.

33. The method of claim 32 further comprising:

including a first filter code in the bitstream to indicate a first filter to be used for decoding the first part; and

including a second filter code in the bitstream to indicate a second filter to be used for decoding the second part;

wherein the second filter differs from the first filter.

34. The method of claim 32 wherein the frame in the encoded video sequence is a bi-directionally predicted frame.

35. A video encoder comprising:

means for setting more than one spatial resolution for encoding plural video frames in a video sequence; and

means for encoding the plural video frames in the video sequence;

wherein the means for encoding the plural video frames includes functionality for encoding a first video frame of the plural video frames at a first spatial resolution and for encoding a second video frame of the plural video frames at a spatial resolution differing from the first spatial resolution, and wherein the means for setting more than one spatial resolution comprises means for choosing spatial resolutions from a set of plural spatial resolutions to reduce blocking artifacts in the video sequence.

36. A multi-resolution method for decoding video, the method comprising:

receiving a multi-resolution signal in a sequence header for a video sequence of plural encoded frames, wherein the multi-resolution signal indicates whether the plural frames in the video sequence are encoded at more than one spatial resolution; and

if the plural frames are encoded at more than one spatial resolution,

decoding a first encoded frame of the plural encoded frames at a first spatial resolution, and

decoding a second encoded frame of the plural encoded frames at a second spatial resolution.

37. The method of claim 36 wherein the second spatial resolution differs from the first spatial resolution by a factor of 2.

38. The method of claim 36 wherein the second spatial resolution comprises a vertical resolution with a vertical scaling factor and a horizontal resolution with a horizontal scaling factor, and wherein the vertical scaling factor differs from the horizontal scaling factor.

39. The method of claim 36 wherein the second spatial resolution is determined adaptively based at least in part on bitrate criteria.

40. The method of claim 36 wherein the second spatial resolution is determined adaptively based at least in part on high-frequency content criteria.

41. The method of claim 36 wherein the second spatial resolution is determined adaptively based at least in part on quantization step size criteria.

42. The method of claim 36 wherein the second encoded frame is down-sampled from an original resolution.

43. The method of claim 42 wherein the second encoded frame is down-sampled from the original resolution using fractional-rate down-sampling.

44. The method of claim 42 wherein the decoding the second encoded frame yields a decoded frame, the method further comprising:

after decoding the second encoded frame, up-sampling the decoded frame, wherein the up-sampling yields a full resolution decoded frame.

45. The method of claim 44 wherein the up-sampling comprises applying a 10-tap filter to the decoded frame.

46. The method of claim 36 wherein plural signal codes in a bitstream indicate the first and second spatial resolutions.

47. The method of claim 36 wherein the second encoded frame is a bi-directionally predicted frame.

48. A computer-readable medium having stored thereon computer-executable instructions for causing a computer programmed thereby to perform the method of claim 36.

49. A multi-resolution method for decoding video, the method comprising:

decoding a first part of an encoded frame in a video sequence at a first spatial resolution; and

decoding a second part of the encoded frame at a second spatial resolution;

wherein the second spatial resolution differs from the first spatial resolution.

50. The method of claim 49 wherein the encoded frame in the video sequence is a bi-directionally predicted frame.

51. A video decoder comprising:

means for receiving a multi-resolution signal in a sequence header for a video sequence, wherein the multi-resolution signal indicates whether plural video frames in the video sequence are encoded at more than one spatial resolution;

means for setting more than one spatial resolution for decoding the plural video frames in the video sequence; and

means for decoding the plural video frames in the video sequence.

52. In a computer system, a computer-implemented method comprising:

receiving pixel data for a video image; and

adaptively changing the spatial resolution of the video image, including computing re-sampled pixel data using a re-sampling filter, wherein the re-sampling filter comprises a six-tap down-sampling filter.

53. The method of claim 52 wherein the computing comprises horizontal and vertical re-sampling, and wherein the horizontal re-sampling is performed prior to the vertical re-sampling.

54. The method of claim 52 wherein the computing comprises:

rounding a number of chrominance samples to a multiple of 8; and

rounding a number of luminance samples to a multiple of 16.

55. The method of claim 52 further comprising repeating the computing for each of plural video images in a video image sequence.

56. A computer-readable medium storing computer-executable instructions for causing the computer system to perform the method of claim 52 during video encoding.

57. In a computer system, a computer-implemented method comprising:

receiving pixel data for a video image; and

adaptively changing the spatial resolution of the video image, including computing re-sampled pixel data using a re-sampling filter, wherein the re-sampling filter comprises a ten-tap up-sampling filter.

58. The method of claim 57 wherein the computing comprises horizontal and vertical re-sampling, and wherein the horizontal re-sampling is performed prior to the vertical re-sampling.

59. The method of claim 57 wherein the computing comprises:

rounding a number of chrominance samples to a multiple of 8; and

rounding a number of luminance samples to a multiple of 16.

60. The method of claim 57 further comprising repeating the computing for each of plural video images in a video image sequence.

61. A computer-readable medium storing computer-executable instructions for causing the computer system to perform the method of claim 57 during video decoding.